Chapter 6.
Alternative Development

The Denny Way/Lake Union CSO Control Project team developed a number of alternatives that would meet the various CSO regulatory requirements described in the previous chapter. The alternatives were developed to a point where possible environmental impacts associated with each alternative could be identified, the CSO control performance of each alternative could be evaluated, and construction and operating costs for each alternative could be estimated.

The control alternatives have been grouped according to their approach to controlling CSOs at the Denny Way and Dexter regulator stations. This chapter begins with a summary of the three basic control approaches, then describes each of the CSO control alternatives developed by the project team. The chapter also describes an outfall alternative evaluation process used to determine specific outfall requirements for the alternatives using a treatment and discharge approach.

6.1. Approaches to CSO Control

The goal of the project team was to determine the most cost-effective CSO control method that would comply with regulatory requirements and provide the greatest water quality benefit to Elliott Bay and Lake Union. Basic approaches to CSO control include sewer separation, on-site CSO treatment and discharge, and storage and conveyance to a treatment plant. The project team developed CSO control alternatives based on each of these approaches.

The CSO control alternatives presented are organized into three groups that are based on the primary approach used for control of CSO flows. Each group represents a different method of accomplishing the CSO control objectives and may contain more than one alternative configuration. There are a total of six CSO control alternatives, broken into the three groups as follows:

Group 1 Partial sewer separation, together with storage and conveyance of the remaining CSO flow to the West Point Treatment Plant. There is only one partial separation alternative, designated as Alternative 1.

Group 2 Storage and at-site CSO treatment before discharge. CSO treatment includes floatable material removal, settleable solids removal, disinfection, and dechlorination. There are three combined storage and at-site CSO treatment alternatives. The alternatives differ according to the treatment requirements each uses as its basis of design. Alternative 2 is based on federal CSO control policy. Alternative 3 is based on an interpretation of CSO regulatory requirements in terms of an intermittent rather than continuous discharge. Alternative 4 is based on a reading of state CSO control requirements that considers those

requirements as essentially identical with those for a primary treatment plant with continuous effluent discharge. Group 2 alternatives all include a City of Seattle (City) pipeline (the City's Phase 2 project) to convey flows collected from the east side of Lake Union to the King County (County) CSO control facilities. All alternatives in this group also require an outfall to discharge treated effluent.

Group 3 CSO storage and conveyance of stored CSO flows to the West Point Treatment Plant. There are two storage and conveyance alternatives. Alternative 5, like Alternative 2, is based on federal CSO control policy (i.e., not more than four to six untreated discharge events per year). Alternative 6 is based on the Washington CSO control mandate of not more than one untreated discharge event per year. Both Group 3 alternatives include a City of Seattle pipeline (the City's Phase 2 project) to convey flows collected from the east side of Lake Union to the County's CSO control facilities.

Table 6-1 lists the discharge requirements for each alternative.

Table 6-1. Discharge Requirements for CSO Control Alternatives

	Group 1	Group 2			Group 3	
	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6
Untreated discharges per year	1	4 to 6	1	1	4 to 6	1
TSS removal (system wide)	50%	35%	50%	50%	35%	50%
Settleable solids (mL/L/hr)	Not applicable	No limit stated	Less than 2	Less than 0.3	Not applicable	Not applicable
Floatable material control	None	Required	Required	Required	Not applicable	Not applicable
Fecal coliform (in units/100 mL) at chronic zone	Not applicable	14 to 43	14 to 43	14	Not applicable	Not applicable
Dechlorination	N/A	Required	Required	Required	N/A	N/A

One of the goals of the Denny Way/Lake Union project is to reduce the discharge of solids to receiving waters. The system concept uses a mass balance approach to measure suspended solids removal. The mass balance approach assumes the following system operational conditions:

- *System Definition*--The CSO treatment system consists of the West Point Treatment Plant, the Mercer Street tunnel, and the Elliott West CSO control facility. The system also has two treated discharge outfall locations--West Point and the new Elliott West CSO outfall. The system also includes one untreated discharge location at the Denny Way outfall.

- *West Point Treatment Capacities*--The West Point Treatment Plant primary treatment and disinfection capacity is 440 mgd, and the plant provides 300-mgd secondary treatment capacity.

- *Overall System TSS Removal*--Total annual discharges from both West Point and the Elliott West CSO outfalls would be less than 50 percent of the total system CSO influent TSS, calculated on a mass (pounds of TSS removed) basis. All CSO flows stored and diverted to the West Point plant would receive an average of 89 percent total suspended solids (TSS) removal, disinfection, and dechlorination before discharge. Eighty-nine percent is not intended to imply secondary treatment, it is the projected aggregate removal based upon primary treatment of 5% of the CSO flows, and secondary treatment of the remaining 95% of flows.

The Department of Ecology (in an August 22, 1996, letter to King County) stated that Ecology "... agree[s] in principle with evaluating the suspended solids removal performance of the whole treatment system on an annual basis... ."

6.2. Group 1 - Partial Sewer Separation Alternative

Partial separation would involve construction of separate storm sewers to divert street runoff from the combined system. Such a project does not contemplate connecting roof drains or parking lots to the new storm sewers. Additional CSO storage and conveyance facilities could be added to such a partial separation project to eliminate all overflows during the one-event-per-year design storm. Such a one-overflow-per-year partial separation project would include the following elements:

- King County storm sewers would be constructed in the areas shown on Figure 6-1 as basins 102 (Denny / Lake Union east), 103 (Denny / Lake Union west), and 104 (Denny local). Those basins total about 700 acres in area. These partial separation projects include about 23.9 miles of new storm sewer pipe, with diameters ranging from 12 to 84 inches. The storm sewers are assumed to be constructed in accordance with all City of Seattle standards and ordinances.

- Once separated, stormwater must be conveyed to Lake Union and / or Elliott Bay for discharge. Stormwater from the western basins (103 and 104) would be discharged into Elliott Bay through four new outfalls. The estimated cost for the new Elliott Bay outfalls is $19.4 million. Stormwater from Basin 102 would discharge to Lake Union through a new 72-inch-diameter outfall at Terry Avenue North and through several other existing outfalls to Lake Union.

- An 8.6 MG-storage tank would be constructed in the south Lake Union area to store flows captured in the City of Seattle's Phase 1 project. An 8.0 MG storage tank would be constructed on the Elliott West site. The tanks would be filled by gravity and drained by pump stations. The pump station required at south Lake Union would have a capacity of 10.0 mgd. A new

diversion structure would be constructed to divert excess flow from the existing Lake Union tunnel to the new Elliott West storage tank via a new 60-inch pipe laid in Elliott Avenue West. A new diversion structure on the central trunk would divert Dexter overflows to the south Lake Union storage tank through a 36-inch pipeline in Mercer Street. A new 70-mgd pump

station would be required to lift overflows from the Elliott Bay interceptor that result from throttling back at Interbay pump station into the storage tank.

- Some form of best management practice (BMP) is necessary to meet NPDES stormwater permit requirements. For purposes of estimating costs, compost filters were selected as the appropriate BMP.

6.3. Group 2 - Storage and CSO Treatment Alternatives

There are three storage and at-site CSO treatment configurations:

- Alternative 2, based on federal CSO control policy as established by the USEPA.
- Alternative 3, based on state requirements for a primary treatment plant interpreted for intermittent CSO discharges.
- Alternative 4, based on state requirements interpreted as they would apply to a primary sewage treatment plant that operates and discharges effluent on a continuous basis.

These alternatives provide combinations of storage and at-site CSO treatment to control untreated discharges to a specific number of annual events. The required annual, untreated discharge frequencies are four to six events per year for the federal CSO control policy and one event per year for the State of Washington's CSO control requirement. For all three alternatives in this group, flows stored and diverted to the West Point Treatment Plant would receive either secondary treatment or primary treatment, disinfection, and dechlorination before discharge.

All three alternatives using the storage and at-site treatment approach employ an underground tunnel for storage of combined wastewater during storm events. Flows in excess of the tunnel storage capacity and conveyance capacity of the existing Elliott Bay interceptor would receive at least the minimum CSO treatment as per the control policy on which the design is based. All would receive floatable material removal, disinfection, and dechlorination.

Treated discharges into Elliott Bay would be discharged through a new, submerged Elliott West outfall at either the 60- to 70-foot or the 150-foot depth below mean lower low water. The evaluation of the Group 2 alternatives began with an evaluation of outfall performance so proper outfall configurations could be selected to allow the alternatives to meet their respective discharge requirements. Flows in excess of the CSO treatment capacity would be discharged into Elliott Bay through the extended Denny Way CSO outfall without any treatment.

All three alternatives in the group would include a City of Seattle Phase 2 pipeline to capture south Lake Union overflows and convey those flows, together with the flows intercepted in the City's Phase 1 project, to the King County improvements.

6.3.1. Outfall Evaluation

For the Group 2, storage and at-site CSO treatment alternatives, effluent treated at the Elliott West CSO control facility would be discharged through a new outfall. In addition, an extension to the Denny Way CSO outfall would be required to discharge untreated CSO away from the beach in Myrtle Edwards Park, where the existing outfall presently discharges during low tide conditions. Such an extension would bring the outfall into compliance with City of Seattle ordinances requiring that all outfalls be submerged during low tide conditions.

Several alternative outfall configurations were developed during the initial stages of the facilities planning work, based on requirements pertaining to disposal of treated effluent. In all, four alternative outfall configurations for discharging treated CSOs have been examined for the Group 2 alternatives. The four configurations include:

1. An outfall with a single-port discharge at a depth of 60 to 70 feet.
2. An outfall with a single-port discharge at a depth of 150 feet.
3. An outfall with a multiple-port (diffuser) discharge at a depth of 150 feet.
4. An outfall with a diffuser discharge at a depth of 300 feet.

The outfall alternatives are presented on Figure 6-2. Each of the four alternatives incorporates the present understanding of Elliott Bay water circulation patterns and vertical water density profiles into a preliminary outfall concept.

The outfall alternatives have some common elements. All four alternative outfall alignments would originate near the Denny Way regulator station, about 2,600 feet south of the Elliott West CSO control facility. There are a number of reasons for the selection of a more southerly starting point for the outfall. The existing Denny Way CSO outfall corridor already has an NPDES permit and was informally suggested by interested agency representatives. Also, terminating any outfall in the designated ship anchorage area would be dangerous from an outfall maintenance/repair standpoint, and obtaining a permit would be a laborious undertaking with uncertain results. The Denny Way location is close to the southern boundary of the anchorage area, and the discharge point could easily be located to the south of the anchorage area boundary. The portion of pipe that traverses the anchorage would be relatively close to the shore and in shallower water where vessels would probably not anchor. All outfall alternatives must take into account possible impacts to treaty-protected tribal commercial fisheries. The outfall must be designed to minimize the possibility of a treaty fishery net snagging on the structure.

Each alternative assumes an outfall diameter of 72 inches, besides sharing a common starting point. This diameter would limit the outfall exit velocity to about 10 feet per second when the Elliott West CSO control facility is discharging a peak, instantaneous flow of about 200 mgd.

Another element common to each the four alternatives is the proposed 96-inch-diameter, 490-foot-long extension to the existing Denny Way CSO outfall. The outfall extension would be constructed through and would terminate just offshore from the sediment cap constructed in 1990 to remediate an area of sediment contamination that

had resulted from local discharge of untreated sewage over a period of many years before the West Point Treatment Plant was built. Termination of an outfall inside the western edge of the sediment cap would result in the scouring away of the cap sands and destruction of the cap. All outfall alternatives are assumed to share a common trench through the sediment cap with the Denny Way CSO outfall extension to hold cap disruption to a minimum.

Two single-port and two multiple-port discharge configurations were examined. The single-port discharges were assumed to be straight-walled, 72-inch-diameter nozzles, tilted upward to help prevent bottom scour around the point of discharge. Different port sizes and spacing were examined for the multiple-port (i.e., diffuser) configurations.

Dilution modeling was performed for each outfall alternative with the UM component of PLUMES software, a dilution model supported by the USEPA. The UM component was used because it allows an estimate of dilution to be made from both single-port and multiple-port discharges. A revised dilution model was developed, using the PLUMES software and the data that had been collected during project refinement, to predict the conservative or "worst case" dilution for each alternative. Those models were then used to calculate dilution rates for each configuration under the various hydraulic conditions the outfall will experience. A prediction of the treated discharge fecal coliform level was also estimated, based on the results of that modeling effort. Finally, construction cost estimates were prepared for each outfall alternative.

Single-Port Discharge at a Depth of 60 to 70 Feet. Under this alternative, outfall discharge would occur at a point just offshore from the Denny Way sediment cap (see Figure 6-2). The point of outfall discharge would be in about 60- to 70-feet of water and located about 490-feet offshore. The outfall would be constructed adjacent to the Denny Way CSO outfall extension. The single discharge port would be 72 -inches in diameter and angled upward from horizontal.

The 60- to 70-foot depth of this alignment corresponds to the depth of water beyond the offshore boundary of the sediment cap. This alternative offers some advantages over the existing shoreline CSO discharge since the point of discharge would be farther out into the Duwamish River plume and would therefore have somewhat better transport characteristics than the current shoreline discharge. As can be seen on Figure 6-3, however, the transport advantage presented for this alternative is limited. Figure 6-3 depicts the results of a drift card release study that was performed as part of the project refinement oceanographic field work. The contour lines on the figure represent the percentage of drift card released in the area immediately offshore from the existing Denny Way CSO outfall that were recovered within inner Elliott Bay. As such, the contour lines offer some insight into how effective the Duwamish River plume is at carrying discharged floatable material out of inner Elliott Bay. For the 60-foot-deep outfall alternative, more than 50 percent of all floatable material not removed in the treatment process will remain within inner Elliott Bay.

The predicted fecal coliform level was estimated for varying discharge flow rates, based on an "end of pipe" technology-based fecal coliform level of 400 colonies per 100 milliliters (mL). As shown on Figure 6-4, the estimated fecal coliform level at the edge of the chronic mixing boundary falls below the Class A marine water fecal coliform excursion limit of 43 colonies per 100 mL for discharge flows less than 80 mgd.

The estimated total capital cost for this alternative, including 30 percent contingency, sales tax and allied costs (36 percent), is $6.6 million (1996 dollars).

Single-Port Discharge at a Depth of 150 Feet. This alternative was formulated to estimate the additional dilution that might be achieved if treated CSOs were discharged through a single-port outfall at greater depth. The outfall discharge port for this alternative would be located about 1,700 feet offshore. The outfall discharge port would be 72 inches in diameter and angled upward.

As shown on Figure 6-2, the outfall discharge would be placed near a point of stable bottom slope located south of the general anchorage area. This outfall configuration would provide greater dilution than an outfall discharging at a 60-foot depth because of a deeper water column in which to dilute the treated effluent. The discharge location would still be near the 50 percent drift card recovery line, so approximately 50 percent of any floatable materials not removed in the treatment process would be carried out of Elliott Bay.

The predicted fecal coliform level was estimated for varying discharge flow rates, based on an "end of pipe" technological based fecal coliform level of 400 colonies per 100 mL. As shown on Figure 6-4, the estimated fecal coliform level at the edge of the chronic mixing boundary falls below the Class A marine water fecal coliform geometric mean limit of 14 colonies per 100 mL for discharge flows less than 80 mgd, and below the excursion limit of 43 colonies per 100 mL up to the predicted maximum peak instantaneous discharge flow of 200 mgd.

The estimated total capital cost for this alternative, including 30 percent contingency, sales tax and allied costs (36 percent), is $12.4 million (1996 dollars).

Multiple-Port Discharge at 150-Foot Depth. A two-pronged diffuser section on the end of the 150-foot-deep outfall was examined to determine if a diffuser would be able to trap the effluent plume below the surface (see Figure 6-2). Each diffuser section would be 400 feet long and 60 inches in diameter. Each diffuser section would be equipped with forty 6-inch-diameter ports, spaced 10 feet apart. Each port was assumed to discharge upward and to provide good flow dispersion over the length of the diffuser sections.

An outfall placed at a depth of 150-feet with diffuser sections would provide greater dilution than a single-port discharge placed at the same depth. However, it would be difficult to trap the effluent plume beneath the surface except at relatively low flow rates. Approximately 50 percent of all floatable material not removed in the treatment process would be transported out of Elliott Bay.

The predicted fecal coliform level was estimated for varying discharge flow rates based on an "end of pipe" technology-based fecal coliform level of 400 colonies per 100 mL. The estimated fecal coliform level at the edge of the chronic mixing boundary falls below the Class A marine water fecal coliform geometric mean limit of 14 colonies per 100 mL, up to the predicted maximum peak instantaneous discharge flow of 200 mgd (Figure 6-4).

The estimated total capital cost for this alternative, including 30 percent contingency, sales tax, and allied costs (36 percent), is $17.4 million (1996 dollars).

Multiple-Port Discharge at 300-Foot Depth. This alternative was formulated to take full advantage of the surface transport "sweet spot" identified by the project refinement oceanographic field work. As shown in Figure 6-4, the "sweet spot" represents an area from which water will move out the inner Elliott Bay more rapidly. This suggests that treated effluent dispersion can be more effective by extending the outfall discharge location to the "sweet spot" location. This alternative was also examined to estimate the deep line diffuser's ability to trap effluent below the surface by taking advantage of the Elliott Bay water column density structure.

This alternative assumed a two-pronged diffuser. Each diffuser section was assumed to be 60-inches in diameter and about 800 feet long. Each diffuser section was assumed to contain fifty-four ports, each 5-inches in diameter and spaced 15-feet apart. Discharge ports were assumed to angled upward and were also assumed to provide good flow distribution along the length of the diffuser sections.

Because of the diffuser and the additional water column over the diffuser, this alternative provided the best dilution of all of the alternatives evaluated. This was also the only discharge point located outside the 50 percent drift card recovery line, indicating that floatable materials are more likely to be transported away from the Elliott Bay shoreline than with any of the other three alternatives.

The predicted fecal coliform level was estimated for varying discharge flow rates, based on an "end of pipe" technology-based fecal coliform level of 400 colonies per 100 mL. As shown on Figure 6-4, the estimated fecal coliform level at the edge of the chronic mixing boundary falls below the Class A marine water fecal coliform geometric mean limit of 14 colonies per 100 mL, up to the predicted maximum peak instantaneous discharge flow of 200 mgd.

The estimated total capital cost for this alternative including 30 percent contingency, sales tax, and allied costs (36 percent) is $40.4 million (1996 dollars).

Selected Outfall Configurations for Alternatives 2 and 3. All four of the outfall alternatives examined would comply with the Class A marine waters chronic fecal coliform limit of 14 colonies per 100 mL based on a monthly geometric mean, with no more than 10 percent (or three days out of the month) exceeding 43 colonies per 100 mL. The design objective for Alternatives 2 and 3 is to not exceed the chronic fecal coliform level of 43 colonies per 100 mL during the maximum daily discharge flow of 80 mgd.

As shown on Figure 6-4, all outfall alternatives are predicted to have chronic fecal coliform levels of 43 colonies per 100 mL or less for the maximum daily flow of 80 mgd. While all of the alternatives will meet the design objective, the single port outfall at 60-

to 70-foot depth was chosen as the outfall configuration for Alternatives 2 and 3 because the total project cost ($6.6 million) is the least cost of the four outfall alternatives. It is almost 50 percent less costly than the second least-cost alternative, the single-port discharge at 150--feet deep.

Selected Outfall Configuration for Alternative 4. Alternative 4 would comply with all CSO treatment requirements, including the Class A marine water standards for chronic fecal coliform of 14 colonies per 100 mL during the estimated maximum daily discharge flow of 80 mgd. As shown on Figure 6-4, the single-port discharge at 60- to 70-foot depth is predicted to have a fecal coliform level of 43 colonies per 100 mL for the maximum daily flow of 80 mgd. Hence it does not meet the design criteria for Alternative 4. Figure 6-4 also shows that the multiple-port discharge alternatives discharging at 150 feet and 300 feet, and the single-port outfall at 150 feet, can all meet the fecal coliform level of 14 colonies per 100 mL for the maximum daily flow of 80 mgd. The single-port outfall at the 150-foot depth was chosen for Alternative 4 because its total project cost ($12.4 million) is the least when compared to the multiple-port discharge at the 150-foot depth ($17.4 million) and the 300-foot deep, multiple-port discharge ($40.4†million).

6.3.2. Alternative 2--Federal CSO Control Policy

The USEPA published its national CSO control strategy in 1989, and then published its *CSO Control Policy* in 1994. The following requirements must be met for the County's Denny Way/Lake Union CSO Control Project to comply with the federal CSO control policy:

- No more than four untreated overflow events on average per year. (NPDES permitting authorities may authorize up to two additional untreated overflows per year, for a total of six.)
- Treated overflows should receive at least primary clarification, solids and floatables disposal, and disinfection of effluent to meet water quality standards and to protect human health and designated uses. "Primary clarification" is defined by USEPA as a process by which at least 35 percent of the suspended solids is removed.
- Compliance with applicable water quality standards.

The specific proposed CSO discharge requirements for Alternative 2 are described below.

Number of Annual Untreated Discharge Events. This alternative would provide a combination of storage and at-site CSO treatment to control untreated discharges to four to six events a year. Design Storm 5 has a recurrence frequency of four to five times a year, thus making Design Storm 5 the design basis for Alternative 2. A CSO control project that controls such a storm by either storing the combined sewer flows and conveying the stored flows to a treatment plant (West Point Treatment Plant) for treatment and disposal, or by storing flows and providing at-site CSO treatment before discharge, is considered adequate to meet the federal CSO control policy. Flows

diverted to West Point would receive either secondary treatment or blended primary / secondary treatment and disinfection.

Flows in excess of storage capacity of the tunnel and the conveyance capacity of the Elliott Bay interceptor would receive floatable material removal and disinfection prior to discharge through the new Elliott West outfall. In addition, flows would be dechlorinated to meet chlorine residual water quality limits.

Suspended Solids Removal. Alternative 2 would, by combining on-site treatment at the Elliott West site and treatment of flows stored at and conveyed to West Point, exceed 35 percent TSS reduction system-wide.

Settleable Solids. Federal CSO control regulations do not have a specific treated-effluent, settleable-solids discharge limit. Flows up to Design Storm 5 that exceed the storage capacity of the Mercer Street tunnel would receive floatable material removal prior to discharge through the new Elliott West outfall.

Disinfection. A disinfection system would be provided. Requirements for CSO treatment facilities may include disinfection requirement at CSO sites that impact or are near water supply intakes, potentially harvestable shellfish areas, or primary contact recreation areas. The Department of Ecology (in its August 22, 1996, letter to King County) stated that Ecology's current position is not to permit non-disinfected discharges of treated sewage. In addition, dechlorination will be provided to meet water quality standards for residual chlorine.

Flows from storms greater than King County Design Storm 5 would produce untreated discharges at the new Denny Way CSO outfall extension. No disinfection would be provided for discharges through the new Denny Way CSO outfall extension.

Water Quality Standards. Alternative 2 would discharge untreated CSOs and treated effluent into Elliott Bay. WAC 173-201A-140 classifies Elliott Bay as Class A marine waters. WAC 173-201A-030(2) defines the applicable water criteria for Elliott Bay. The fecal coliform water quality limits and residual chlorine restriction are assumed to be the standards of greatest concern. This alternative would meet the fecal coliform and residual chlorine limits, as described for Alternative 3.

Alternative 2 would consist of the following facilities: CSO storage tunnel; new outfalls; CSO treatment; and conveyance pipelines, diversion structures, and regulator. The facilities are described below.

A 9.5-foot-diameter Mercer Street tunnel would provide 3.1 million gallons of CSO storage. A tunnel diameter of 9.5 feet is the minimum size that could be cost-effectively constructed, based on a recent analysis made by King County for the Alki project. New south Lake Union CSO pipelines, central trunk diversion structure, and Lake Union tunnel regulator would be constructed in the south Lake Union area to convey flows from the City of Seattle Phase 2 project, existing Lake Union tunnel, and existing central trunk to the east end of the new Mercer Street tunnel for CSO storage.

A new Elliott West CSO pipeline and Denny Way diversion structure would also be constructed to convey flows from the downstream end of the existing Lake Union

tunnel to the Elliott West CSO facility. There would be a 90-mgd influent pump station at the Elliott West CSO facility which would pump flows from the existing Elliott Bay interceptor and the new Elliott West CSO pipeline into the Mercer Street tunnel for storage. There would also be flow control structures to transfer flows among the tunnel, Elliott Bay interceptor, and Elliott West CSO pipeline.

The Mercer Street tunnel would store flows until the Elliott Bay interceptor has sufficient capacity to accommodate additional flows without overflowing. The stored flow, including settled solids and floatable material, would be released into the Elliott Bay interceptor and conveyed to the existing West Point Treatment Plant for treatment, disinfection, and disposal.

Flows in excess of storage capacity of the tunnel and the conveyance capacity of the Elliott Bay interceptor would be discharged into Elliott Bay through the on-site treatment facility, a 120-mgd effluent pump station, and the new Elliott West outfall. The floatable material control facility would trap floatable material and prevent its discharge into Elliott Bay. The effluent pump station would also serve as the location for injection of disinfection chemicals. Disinfection chemical contact time would be provided through the Elliott West force main that would transport the disinfected wastewater to the new Elliott West outfall. Dechlorination chemicals would be injected at the end of the force main, just upstream from the outfall.

6.3.3. Alternative 3 - CSO Treatment for Intermittent Discharge Plants

As described in Chapter 5, WAC Chapter 173-245 governs the operation and construction of CSO control facilities. That chapter imposes a number of control requirements, including:

- An average of one untreated overflow event per outfall per year.
- Maximization of CSO flows to secondary treatment facilities.
- Total suspended solids (TSS) reduction.
- Disinfection.
- Compliance with applicable water quality standards
- Effluent settleable solids concentration limit.

Alternative 3 will comply with CSO requirements, as described below.

Number of Annual Untreated Discharge Events. This alternative would provide a combination of storage and at-site CSO treatment to control untreated discharges to one untreated discharge event a year (i.e., to control King County's Design Storm 6). A CSO control project that controls Design Storm 6 either by storing the combined sewer flows and conveying them to a treatment plant (West Point) for treatment and disposal, or by providing at-site CSO treatment before discharge, meets state CSO treatment requirements. Flows diverted to West Point would receive either secondary treatment or blended primary/secondary treatment and disinfection.

Flows in excess of storage capacity of the tunnel and the conveyance capacity of the Elliott Bay interceptor would receive floatable material removal and disinfection prior to discharge through the new Elliott West outfall. In addition, flows would be dechlorinated to meet chlorine residual water quality limits.

Flows from storms greater than King County Design Storm 6 would produce untreated discharges at the new Denny Way CSO outfall extension. No CSO treatment would be provided for discharges through the new Denny Way CSO outfall extension.

Suspended Solids Removal. Alternative 3 would, by combining on-site treatment at the Elliott West site and treatment of flows stored at and conveyed to West Point, exceed 50 percent TSS reduction in the project system.

Settleable Solids. The Ecology standard of 0.3 mL/L/hr for effluent settleable solids has been applied at the Carkeek Park Treatment Plant as a monthly average. The Carkeek Park plant effluent settleable solids have ranged from 0.1 to 4 mL/L/hr, and the Alki Treatment Plant effluent settleable solids values have ranged from 0.1 to 5†mL/L/hr (based on recent operating data during combined sewer storm events).

There have been several months when only one Carkeek Park discharge event occurred. The monthly settleable solids average for those months equals the value measured for the single occurrence. Since effluent settleable solids concentrations depend to some extent on influent concentrations that have a natural variation, it is very difficult to achieve the Ecology limit on each and every discharge occurrence without a major treatment process such as dissolved air flotation thickening. Operating experience at the Alki Treatment Plant during storm events indicates similar variation in effluent settleable solids concentrations.

If the settleable solids limit were taken as an average over many events, there is an increased probability that the effluent settleable solids concentrations will meet the 0.3 mL/L/hr limit. For example, a continuously operating treatment plant will have many days during a typical calendar month when the effluent is less than 0.3 mL/L/hr, and a few days with higher values. The monthly average is usually below the Ecology limit because of the frequency of lower values. For this alternative, the system will discharge intermittently (about 10 to 15 times per year), usually during the larger rainfall events when the effluent settleable solids concentrations would be higher, even at continuously operating plants.

Application of the Ecology settleable solids limit as a short-term (e.g., monthly) average is inappropriate for a CSO treatment plant. A more appropriate method is to define a maximum effluent settleable solids value, which, if met in statistical context with all other expected values, provides assurance that the long-term average of all events will meet the standard. A similar approach is used by the USEPA in setting toxicity criteria, where effluent measurements are infrequent. In the toxicity criteria approach, the maximum criteria is set so there is some confidence (typically the 95 percent probability level) that values at or below the limit are members of a population of measurements whose long-term mean will be equal to or below the desired limit. The mean and standard deviations are determined from a given series of measurements--the desired long-term limit plus a multiple of the standard deviation is used to define the maximum value expected within the specified confidence limit. Because recorded data of this type is always above some detection limit, with the highest frequency of values near the detection limit, it is necessary to derive statistics using the logarithms of the recorded values and transform the results back to normal values (antilogarithms).

For Alternative 3, it is proposed that settleable solids limits be taken as a long-term geometric mean of 0.3 mL/L/hr, with compliance measured by a maximum per event limit of 2.0 mL/L/hr. This corresponds to the 95 percent confidence limits from analysis of Carkeek Park data.

Disinfection. A disinfection system would be provided. Requirements for CSO treatment and disinfection are the same as Alternative 2. In addition, dechlorination would be provided to meet water quality standards for residual chlorine.

Water Quality Standards. Alternative 3 would discharge untreated CSOs and treated effluent into Elliott Bay. WAC 173-201A-140 classifies Elliott Bay as Class A marine waters. WAC 173-201A-030(2) defines the applicable water criteria for Elliott Bay. The fecal coliform water quality limits and residual chlorine restriction are assumed to be the standards of greatest concern. Preliminary guidance from Ecology indicates that acute aquatic standards will apply to these brief, intermittent discharges.

Ecology has suggested an end-of-pipe coliform limit of 400 colonies per 100 mL, the weekly average limit that applies to secondary treatment plants. State requirements specify a receiving water standard for fecal coliforms, requiring that the monthly geometric mean of concentrations be equal to or less than 14 colonies per 100 mL and that no more than 10 percent of samples (3 days per month) can exhibit concentrations greater than 43 colonies per 100 mL. This standard is applied at the edge of the outfall chronic mixing zone boundary.

Ecology defines chronic flow conditions for dilution modeling in estuaries as the maximum monthly flow condition for continuously operating treatment plants and accepts the maximum monthly average flow occurring in the last three years. The maximum monthly flow definition for chronic standards is less straightforward for intermittent discharges. Since treated discharge occurrences are infrequent and usually small (75 percent of the predicted event discharge volumes are less than 10 MG, and 90 percent are less than 30 MG), the discharges will not cause the geometric mean of the receiving water fecal coliform concentrations to exceed 14 colonies per 100 mL and will not exceed the maximum monthly chronic fecal coliform excursion limit of 43 colonies per 100 mL. Dechlorination would be provided to meet the acute chlorine residual limit of 0.013 mg/L for each treated discharge. No disinfection would be provided for untreated discharges through the Denny Way CSO outfall extension since the discharges would not occur more than one time a year, on average.

Alternative 3 would consist of the following facilities: CSO storage tunnel; new outfalls; CSO treatment; and conveyance pipelines, diversion structures, and regulator. The facilities are described below.

A 14.5-foot-diameter Mercer Street tunnel would provide 7.1 million gallons of CSO storage. New south Lake Union CSO pipelines, central trunk diversion structure, and Lake Union tunnel regulator would be constructed in the south Lake Union area to convey flows from the City of Seattle Phase 2 project, existing Lake Union tunnel, and existing central trunk to the east end of the new Mercer Street tunnel for storage.

A new Elliott West CSO pipeline and Denny Way diversion structure would also be constructed to convey flows from the downstream end of the existing Lake Union tunnel to the Elliott West CSO facility. There would be a 120-mgd influent pump station at the Elliott West CSO facility that would pump flows from the existing Elliott Bay interceptor and the new Elliott West CSO pipeline into the Mercer Street tunnel for CSO storage. There would also be flow control structures to transfer flows among the tunnel, Elliott Bay interceptor, and Elliott West CSO pipeline.

The Mercer Street tunnel would store flows until the Elliott Bay interceptor had sufficient capacity to accommodate additional flows without overflowing. The stored flow, including settled solids and floatable material, would be released into the Elliott Bay interceptor and conveyed to the existing West Point Treatment Plant for treatment, disinfection, and disposal.

6.3.4. Alternative 4 - CSO Treatment for Continuous Discharge Plants

Similar to Alternative 3, Alternative 4 would also satisfy the requirements of WAC Chapter 173-245. The design basis for Alternative 4 is compliance with all of the CSO control requirements described in Chapter 174-245 as those requirements would be interpreted for a primary treatment plant with a continuous discharge.

Number of Annual Untreated Discharge Events. This alternative would provide a combination of storage and at-site CSO treatment to control untreated discharges to one event a year (i.e., to control King County's Design Storm 6). A CSO control project that controls Design Storm 6 by either storing the combined sewer flows and conveying them to a treatment plant (West Point) for treatment and disposal, or by storing flows and providing at-site CSO treatment before discharge, meets state CSO treatment requirements. Flows diverted to West Point would receive either secondary treatment or primary treatment and disinfection.

Flows in excess of storage capacity of the tunnel and the conveyance capacity of the Elliott Bay interceptor would receive floatable material removal, settleable solids removal, and disinfection prior to discharge through the new Elliott West outfall. In addition, flows would be dechlorinated to meet chlorine residual water quality limits.

Flows from storms greater than King County Design Storm 6 would produce untreated discharges at the new Denny Way CSO outfall extension. No CSO treatment would be provided for discharges through the new Denny Way CSO outfall extension.

Suspended Solids Removal. By combining on-site treatment at the Elliott West site and treatment of flows stored and conveyed to West Point, Alternative 4 would exceed the 50 percent TSS removal criterion.

Settleable Solids. The system would meet the 0.3 mL/L/hr discharge limit for settleable solids for every discharge out the Elliott West or West Point outfalls. Flows in excess of storage capacity of the tunnel and conveyance capacity of the Elliott Bay interceptor would be conveyed to storage/treatment tanks on the Elliott West site, where the wastewater would be subjected to dissolved air flotation thickening to produce a settleable solids effluent concentration of 0.3 mL/L/hour for each treated discharge event. Dissolved air flotation separates solid particles from the liquid phase by

introducing air bubbles to the liquid. The bubbles would attach to the solid particles, which then rise to the surface where they would be skimmed off. Heavier particles would settle to the bottom of the storage/treatment tanks and be removed.

Disinfection. A disinfection system would be provided. Requirements for CSO treatment and disinfection are the same as Alternative 2. In addition, dechlorination will be provided to meet water quality standards for residual chlorine, as described for Alternative 2.

Water Quality Standards. Alternative 4 would discharge untreated CSOs and treated effluent into Elliott Bay. WAC 173-201A-140 classifies Elliott Bay as Class A marine waters. WAC 173-201A-030(2) defines the applicable water criteria for Elliott Bay. The fecal coliform water quality limits and residual chlorine restriction are assumed to be the standards of greatest concern. This alternative would need to meet the chronic fecal coliform limit of 14 colonies per 100 mL and the chronic chlorine residual limit of 0.0075 mg/L for each treated discharge. No disinfection would be provided for untreated discharges through the new Denny Way CSO outfall extension.

Alternative 4 would consist of the following facilities: CSO storage tunnel; new outfalls; CSO treatment; and conveyance pipelines, diversion structures, and regulator. The facilities are described below.

A new 9.5-foot-diameter Mercer Street tunnel would provide 3.1 million gallons of CSO storage capacity, and storage/treatment tanks at the Elliott West CSO facility would provide another 4.0 MG of storage. New south Lake Union CSO pipelines, central trunk diversion structure, and Lake Union tunnel regulator would be constructed in the south Lake Union area to convey flows from the City of Seattle Phase 2 project, existing Lake Union tunnel, and existing central trunk to the east end of the new Mercer Street tunnel for CSO storage.

A new Elliott West CSO pipeline and Denny Way diversion structure would also be constructed to convey flows from the downstream end of the existing Lake Union tunnel to the Elliott West CSO facility. There would be a 120-mgd influent pump station at the Elliott West CSO facility which would pump flows from the existing Elliott Bay interceptor and the new Elliott West CSO pipeline into the Mercer Street tunnel for CSO storage. There would also be flow control structures to transfer flows among the tunnel, Elliott Bay interceptor, and Elliott West CSO pipeline.

Flows in excess of storage capacity of the tunnel and conveyance capacity of the Elliott Bay interceptor would be transferred to the 4-MG storage/treatment tanks located at the Elliott West CSO facility. The stored flow, including settled solids and floatable material, would be released into the Elliott Bay interceptor and conveyed to West Point for treatment, disinfection, and disposal. Flows from the tanks in excess of storage capacity would be discharged through a 200-mgd effluent pump station and outfall. The tanks would also serve as chlorine contact basins, besides providing dissolved air flotation thickening to remove settleable solids. Dechlorination chemicals would be injected at the effluent pump station prior to being conveyed through the Elliott West force main to the new Elliott West outfall. Flows in excess of Design Storm 6 would be discharged without treatment through the extended Denny Way CSO outfall.

6.4. Group 3 - Storage and Conveyance Alternatives

There are two configurations for storage and conveyance to West Point:

- Alternative 5, based on the federal CSO control policy.
- Alternative 6, based on state CSO control requirements.

These alternatives would store sufficient volumes of combined sewage flows to control untreated discharges to a specified number of annual events. The annual untreated discharge frequencies are four to six events per year for the federal CSO control policy and one event per year for the Washington state CSO control requirement. Flows stored and diverted to the West Point Treatment Plant would either receive secondary treatment or primary treatment. The West Point Treatment Plant has been permitted for primary treatment and disinfection up to 440 mgd and secondary treatment up to 300 mgd. It is anticipated that most of the CSO flows would be transferred to the West Point plant when secondary treatment capacity is available.

Flows in excess of the tunnel storage capacity and existing Elliott Bay interceptor conveyance capacity would be allowed to discharge untreated into Elliott Bay through an extension to the Denny Way CSO outfall at a discharge depth of 60 to 70 feet below mean lower low water.

6.4.1. Alternative 5 - Federal CSO Control Policy

The following requirements must be met for the storage and conveyance alternative to comply with the federal CSO control policy:

- No more than four untreated overflow events on average per year. (NPDES permitting authorities may authorize up to two additional untreated overflows per year, for a total of six.)
- CSO volume and pollutant discharge reduction by maximizing flow to publicly owned treatment plant for treatment.

This alternative would store sufficient quantities of combined sewer flows to control untreated discharges to four to six events a year. In other words, Alternative 5 would store flows during King County Design Storm 5. Flows in excess of Design Storm 5 would be discharged untreated approximately four to six times a year.

A 24.5-foot-diameter Mercer Street tunnel would provide 20.5 million gallons of CSO storage. New south Lake Union CSO pipelines, central trunk diversion structure, and Lake Union tunnel regulator would be constructed in the south Lake Union area to convey flows from the City of Seattle Phase 2 project, existing Lake Union tunnel, and existing central trunk to the east end of the new Mercer Street tunnel for CSO storage.

A new Elliott West CSO pipeline and Denny Way diversion structure would also be constructed to convey flows from the downstream end of the existing Lake Union tunnel to the Elliott West CSO facility. There would be a 120-mgd influent pump station at the Elliott West CSO facility that would pump flows from the existing Elliott Bay

interceptor and the new Elliott West CSO pipeline into the Mercer Street tunnel for CSO storage. There would also be flow control structures to transfer flows among the tunnel, Elliott Bay interceptor, and Elliott West CSO pipeline.

Because this alternative provides for control by storage only, the only treated discharges would occur at West Point. Therefore, the configuration does not include a new outfall to Elliott Bay. The existing Denny Way CSO outfall would be extended, however.

The Mercer Street tunnel would store flows up to King County Design Storm 5 until the Elliott Bay interceptor has sufficient capacity to accommodate additional flows without overflowing. The stored flow, including settled solids and floatable material, would be released into the Elliott Bay interceptor and conveyed to the existing West Point Treatment Plant for treatment, disinfection, and disposal.

Flows from storms greater than King County Design Storm 5 would produce untreated discharges at the extended Denny Way CSO outfall. No CSO treatment would be provided for discharges through the new Denny Way CSO outfall extension.

6.4.2. Alternative 6 - State CSO Control Requirements

A storage-only configuration must do two things in order to satisfy state CSO control requirements. It must:

- Reduce untreated discharges to no more than an average of one per year.
- Maximize CSO flow diversion to secondary treatment facilities.

The design basis for Alternative 6 is to store sufficient quantities of combined sewer flows to control King County Design Storm 6, the once per year storm event. Twin 26-foot-diameter tunnels would be required to provide the 45.3 million gallons of storage needed to control Design Storm 6. New south Lake Union CSO pipelines, central trunk diversion structure, and Lake Union tunnel regulator would be constructed in the south Lake Union area to convey flows from the City of Seattle Phase 2 project, existing Lake Union tunnel, and existing central trunk to the east end of the new Mercer Street tunnel for CSO storage.

A new Elliott West CSO pipeline and Denny Way diversion structure would also be constructed to convey flows from the downstream end of the existing Lake Union tunnel to the Elliott West CSO facility. There would be a 120-mgd influent pump station at the Elliott West CSO facility which would pump flows from the existing Elliott Bay interceptor and the new Elliott West CSO pipeline into the Mercer Street tunnel for CSO storage. There would also be flow control structures to transfer flows among the tunnel, Elliott Bay interceptor, and Elliott West CSO pipeline.

Because this alternative provides for control by storage only, the only treated discharges would occur at West Point. Therefore, this alternative does not include a new outfall to Elliott Bay. The existing Denny Way CSO outfall would be extended, however.

Twin 26-foot-diameter Mercer Street tunnels would store flows up to King County Design Storm 6 until the Elliott Bay interceptor has sufficient capacity to accommodate additional flows without overflowing. The stored flow, including settled solids and

floatable material, would be released into the Elliott Bay interceptor and conveyed to the existing West Point Treatment Plant for treatment, disinfection, and disposal.

Flows from storms greater than King County Design Storm 6 would produce untreated discharges at the Denny Way CSO outfall extension located approximately 60 to 70 feet below mean lower low water. No CSO treatment would be provided for discharges through the new Denny Way CSO outfall extension.

6.5. Summary of Alternatives

Table 6-2 summarizes all of the various project elements that each alternative requires.